Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
Inquiry Regarding Carrier Current Systems including Broadband over Power Line Systems	)	**ET Docket No.** 03-104
By: Michael C. Tope	)	

To: The Office of Engineering and Technology

Reply to Comments of Current Technologies, LLC

1.) Michael C. Tope respectfully submits these reply comments in response to the comments submitted by Current Technologies, LLC in the matter of Inquiry Regarding Carrier Current Systems including Broadband over Power Line Systems (ET Docket No. 03-104)[1]. As a matter of background, I am an electrical engineer involved in radio frequency and microwave equipment design. I hold a Bachelor of Science degree in Electrical Engineering (with honors) from the Ohio State University and have 14 years of professional experience which includes airborne antenna design, cable television (CATV) equipment design, microwave multipoint distribution system (MMDS) equipment design, very-small aperture satellite terminal (VSAT) equipment design, and spaced–based remote sensing equipment design. I currently work at the NASA Jet Propulsion

Laboratory in Pasadena, California, a federally-funded research and development center (FFRDC) where I am employed as an RF and Microwave design engineer. I am also a FCC licensed amateur extra class radio operator, call sign W4EF.

A. Introduction

2.) In their comments to ET Docket 03-104, Current Technologies, LLC makes a number of claims about the nature of BPL technology and its propensity to cause harmful interference to licensed radio services operating in the HF radio spectrum. I offer my reply comments as a rebuttal to these claims, which I intend to show, are based on dubious reasoning or incorrect technical justifications.

B. Interference Baseline

3.) In section E on page 12 of their comments, Current Technologies, LLC states the following:

> *"We are starting with a noisy radio-frequency environment, and the Commission must take that into account in assessing the impact of BPL. No BPL regulation can "re-quiet" the environment back to the pristine state that some commenters prefer. Even before the comment due date, this docket showed over 1500 filings, many very similar, most grossly overstating the interference potential of*

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[1] Comments of Current Technologies, LLC (July 7, 2003)

BPL. These are written with little or no understanding of BPL technology. Current Technologies agrees with the need to prevent added real-world harmful interference to licensed services. We urge the Commission to carry out its analyses using models and parameters that accurately reflect both the likely emissions from BPL and the interference susceptibility of other services under actual operating conditions."

4.) These statements strike me as an attempt to characterize those with interference concerns from BPL as being unreasonable. Background noise levels encountered in the HF frequency bands very greatly with frequency, type of location, time of day, and level of solar activity. Average levels for daytime and nighttime conditions for business, residential, rural, and quiet rural locations are well documented by international standards bodies[2]. What is really at issue is whether or not a broadband unintentional part 15 emitter radiating at or near the regulatory limits will cause harmful interference to licensed radio services. Part 15 of 47 C.F.R.[3] defines harmful interference as follows:

"<u>Harmful interference</u>. Any emission, radiation or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly

[2] ITU. *"Radio Noise"*, ITU-R P.372-6, Geneva.

[3] See 47 C.F.R. §15.3(m)

interrupts a radiocommunications service operating in accordance with this Chapter."

5.) With regard to BPL, there is a solid analytical basis[4] as well as a record of empirical data[5, 6, 7], which suggests that BPL will seriously degrade or repeatedly interrupt an HF radio station which is located in close proximity to a BPL system. These concerns are based on an experience base of current "real world" ambient noise levels compared with theoretical projections as well as actual field measurements of radiated emissions from BPL systems. For example, using the recommendations in ITU-R P.372-6, a typical ambient noise level for a HF radio station operating at 14 MHz in a noisy urban setting with a horizontally polarized ½ wave doublet antenna would be on the order of +5dB μV/meter as measured in a 2.7 KHz bandwidth. If a BPL system operating at the current limits imposed by part 15 for radiated emissions[8] happened to pass within 100 feet of the ½ wave doublet antenna of this HF radio station, then the noise level seen by the HF radio station could easily rise from +5dBμV/meter to

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[4] *"Calculated Impact of PLC on Stations Operating in the Amateur Radio Service"*, Ed Hare, presented at the November 15, 2002 IEEE/ANSI C63 EMC Standards Committee meeting in Rockville, Maryland.

[5] *"EMC: The Impact of Power Line Communications*, *Part 1*", Diethard Hansen, Compliance Engineering Magazine, 2003 Annual Reference Guide.

[6] *"Technical EMI Problems in PLC Systems, Part 2"*, Diethard Hansen, Compliance Engineering Magazine, 2003 Annual Reference Guide.

[7] Video showing results of American Radio Relay League EMI surveys of BPL Field Trial Sites in MD, VA, PA and NY: http://216.167.96.120/BPL_Trial-web.mpg

[8] See 47 C.F.R. §15.209 - "*Radiated emission limits – general requirements*"

+25dBμV/meter. In this case, the emissions from the part 15 compliant BPL system would cause a +20dB increase over and above the very high “real world” noise floor seen by the user of the incumbent radio service. When we cast this +20dB SNR reduction in the form of range “degradation”, we find that it would represent a factor of 10 reduction in communications range over a free space communications link (inverse square law). When put in terms of recovery from interference, consider the fact that the HF radio station at the other end of this BPL degraded communications link would need to increase EIRP by +20dB in order to recover to the pre-BPL SNR. For a 1500 watt HF station operating at 14 MHz using a ½ wave doublet antenna, a +20dB EIRP increase would require either an increase in transmitter output power from 1500 watts to 150 Kilowatts, or expansion of the 33’ long doublet antenna to a multi-tower curtain array covering many acres of land[9]. In either case, to characterize the impact of and recovery from the BPL interference as non-trivial would be a gross understatement. For radio stations operating in quiet rural locations, the degradation from a nearby BPL emitter operating at regulatory limits would be even greater (35 to 45dB SNR reduction)[10].

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[9] A 20dB increase in antenna gain would be equivalent to a factor of 100 increase in effective radiating area.

[10] ITU. *“Radio Noise”*, ITU-R P.372-6, Geneva.

C. Point Source Emissions

6.) In the following statement, Current Technologies, LLC claims that BPL uses electrical power "wires" only as a conducted transmission medium[11]:

> *"POINT-SOURCE EMISSIONS. Some parties to this proceeding assume the entire length of a BPL-equipped power line emits radio-frequency noise, and hence evoke the frightening image of a miles-long transmitting antenna. That is simply wrong. BPL emissions come almost entirely from a short segment of line immediately adjacent to where the BPL device is attached. From a few meters away, the signal closely resembles that from a point source. In that respect it is much like other common sources of radio-frequency noise, such as computers and household appliances. BPL uses the wires only as a conducted transmission medium, and has no more inherent propensity for causing interference than does any other unintentional digital emitter."*

7.) This is an example of wishful thinking that ignores the physical reality of the structure of electric power transmission lines. Overhead medium voltage power transmission lines used for delivering electric power to residential neighborhoods typically use a conductor spacing of between 24" to 48".

[11] Comments of Current Technologies, LLC, § F, page 14.

Because this spacing represents a significant portion of a wavelength at HF frequencies, the EM fields associated with differential-mode excitation of the transmission line do not completely cancel as they would in a high frequency balanced transmission line with closely spaced conductors. This will result in significant radiation along the entire length of the RF energized electric power transmission line. In fact, computer modeling of a 100 foot long section of RF energized overhead electric power transmission line (40' height above average ground, 24" conductor spacing) using a Numerical Electromagnetics Code[12] antenna modeling program[13] indicates that the electric field as measured at a distance of a few meters from the line would be very uniform along the entire length of the line. Even in the case where the line is terminated with a very pathological mismatch, the electric field intensity as observed along the length of the line remains reasonably uniform (uniform level with standing wave superimposed). At smaller distances (less than a hundred meters), this type of emitter would be best represented as a line source. Any representation that an RF energized BPL transmission line would appear as a point source emitter at a distance of a few meters is patently false and simply ignores the physical reality of this type of transmission medium. It is, in fact, the "wires" that are the distinguishing feature of BPL emitters. Most other unintentional emitters radiate as the result of incidental leakage of RF energy through power cables and

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[12] J.K. Breakall, G.J. Burke, and E.K. Miller, "The Numerical Electromagnetics Code", Lawrence Livermore National Lab., Document UCRL-90560, 1984.

[13] EZNEC version 3.0, Antenna Software by W7EL, P.O. Box 6658, Beaverton, Oregon 97007 U.S.A.

openings in their enclosures. Harmful interference from such devices can easily be mitigated by filtering of power leads and improved shielding. In the case of a BPL system, the level of radiated energy emanating from the power lines is inextricably linked by the laws of physics to the level of conducted energy intentionally impressed on those lines. One can only reduce the level of radiated energy by reducing the level of conducted energy, or by changing the structure of the transmission line. Statements, which exclaim that "lines" are only meant to conduct and therefore do not radiate, are the results of wishes not physical reality.

D. Aggregation

8.) In their comments Current Technologies states that BPL signals do not "aggregate" across multiple BPL devices[14]:

> *"NO AGGREGATION. Some parties likewise assume that noise signals from multiple BPL devices will aggregate harmfully. One or two BPL devices may not be a problem, they say, but additive emissions from tens of thousands over a small area will raise the noise floor. That, too, is incorrect. An Access BPL system has one medium-voltage device at each transformer, but only one of those on a BPL distribution leg -- typically many blocks long -- can transmit at a time. Low-voltage devices, including user modems,*

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[14] Comments of Current Technologies, LLC, § F, page 14

may be closer together, but the HomePlug standard allows only one such device served by a given transformer to transmit at a time. The total emissions from all the houses served by one transformer add up to only one modem. And when the signals from devices at one transformer reach the next transformer, they are too attenuated to add significantly. There is no harmful aggregation."

9.) The argument for "aggregation" concerns the additive effect of a large number of BPL sources distributed over a large geographically area (e.g. a whole metropolitan area) propagating via ionospheric skywave to a distant receiver. In this case, all of the BPL sources are essentially equidistant from the receiver and hence would add by a factor 10*log(N), where N is the number of BPL sources transmitting simultaneously. This is clearly not the same as comparing the effect of 1 nearby source to 10 sources that are much further away[15]. In the case of a nearby receiver, it is sufficient to assume a field strength that is consistent with the part 15 limit when evaluating the interference potential for BPL[16]. The extent to which aggregation will be a problem will depend on the number of BPL sources that are transmitting simultaneously. At very high levels of deployment (e.g. 100 simultaneous BPL sources per square mile across a large metropolitan

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[15] Comments of Current Technologies, LLC, § F, page 15, footnote 25.

[16] Since this is the scenario which will deliver the highest data throughput for subscribers and since many BPL proponents are arguing for relaxation of the part 15 limits, it is logical to assume that it will be common practice for BPL systems to be run as close to part 15 emission limits as possible.

area), the potential for aggregation becomes very real[17]. Even more troubling than the issue of aggregation is the issue of ubiquity. At high levels of deployment, the probability that BPL systems will pass in close proximity to licensed HF users becomes very high.

E. Effect of Wide Bandwidth

10.) In their comments Current Technologies state that the wide bandwidth of BPL signals has no bearing on its propensity to interfere with any given receiver[18]:

> *"MINIMAL EFFECT OF WIDE BANDWIDTH. Some parties claim that BPL devices are more interfering than other unintentional emitters, such as computers or appliances, because they emit over a wide bandwidth. But emissions outside a victim receiver's passband have no significant effect on interference to that receiver. For example, a two-way radio with a 12.5 kHz receiver bandwidth is not affected by an interference source at frequencies outside that bandwidth. The overall bandwidth of a BPL system has no bearing*

[17] At an average spacing of 500' between simultaneous BPL emitters (100 sources per square mile), a 900 square mile metropolitan area (30 miles x 30 miles) could contain as many as 90,000 simultaneous BPL emitters. With an individual emitter output power spectral density of –50dBm/Hz (-16 dBm in a 2.7 KHz bandwidth), the aggregate RF signal level reaching a distant observation point from this metropolitan area would be equivalent to the signal level caused by a single BPL emitter driving 2.5 watts of RF power in a 2.7 KHz bandwidth to an overhead powerline located in the center of this metropolitan area.

on its propensity to interfere with any given receiver. In principle, perhaps, the higher bandwidth might be said to impact more receivers from a given BPL system. But it does not happen that way."

11.) Again this ignores the issue of ubiquity. While it may be true that a properly designed "victim" receiver is generally only susceptible to energy falling inside its passband, the bandwidth of the subject unintentional radiator is vitally important if its bandwidth encompasses a significant portion of the spectrum utilized by the effected radio service. In the case of an emission from a narrowband unintentional radiator, the probability that emissions will overlap the passband of "any given receiver" is relatively low. And if overlap does occur, the chances are high that output frequency of the unintentional radiator can be adjusted, or that the effected radio service can utilize a nearby channel, thus avoiding harmful interference. Contrast this with the emissions from a wideband unintentional radiator such as BPL emitting a relatively constant power spectral density across a large swath of spectrum[19, 20]. In the latter case, there will be a very high probability that the wideband emissions from the unintentional radiator will fall in

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[18] Comments of Current Technologies, LLC, § F, page 15

[19] Since part 15 limits in the HF region are specified in a 9KHz measurement bandwidth, the wider bandwidth of BPL signals does not necessarily imply a lower power spectral density than a narrowband emitter.

[20] It is useful here to compare the EIRP of a wideband emitter operating at part 15 limits versus a narrowband emitter operating at the same prescribed limits. For broadband (1.705 to 30 MHz) emitter radiating at the part 15 limit (+30μV/m field at 30 meters), the total radiated power is 3400 times greater than the RF power emanating from a 9 KHz wide emitter operating at the same part 15 limit.

the receiver passband of a nearby licensed radio service. Also one should consider that when interference does occur, it will be very difficult if not impossible to remedy since neither the operating frequency of the emitter nor the frequency of the affected service can be adjusted to avoid interference.

F. Permissible Emission Levels

12.) In section F on page 16 of their comments, Current Technologies, LLC makes the following statement with regard to the relationship between the mounting location of a BPL device and the level of expected emissions:

> *"In particular, the Commission should recognize that a BPL device mounted high on a pole or inside a metal curbside enclosure can safely be allowed somewhat higher emissions levels than a device used inside a residence":*

13.) This would be true if the RF output of the BPL device were not connected to an overhead powerline. As stated previously, the bulk of the interference potential from BPL lies in the physical properties of the transmission medium (e.g. the overhead electric powerlines) used to connect BPL nodes, not in the construction and design of the BPL line equipment.

H. Meeting Absolute Emission Limits vs. Not Causing Harmful Interference

14.) In their comments, Current Technologies, LLC makes the following statement with regard to emissions limits[21]:

> *"Because current In-House BPL devices transmit one at a time, there is no basis for setting their limits below Class B, which any receiver should be expected to tolerate".*

15.) Receivers of stations operating within the framework of a licensed service are not "expected" to tolerate the absolute limits set forth in part 15 if those levels of emissions result in harmful interference to the licensed service. The emission limits are there simply to place a sensible cap on the amount of RF radiation a part 15 device can produce thereby reducing the chances that it will cause harmful interference[22]. In those cases where the unintentional radiator causes harmful interference to a license radio service, part 15 is very clear, the onus is on the operator of the unintentional radiator to curb the interference.

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[21] Comments of Current Technologies, LLC, § F, page 16.

[22] 47 C.F.R. §15.15(c) "Parties responsible for equipment compliance should note that the limits specified in this Part will not prevent harmful interference under all circumstances. Since the operators of Part 15 devices are required to cease operation should harmful interference occur to authorized users of the radio frequency spectrum, the parties responsible for equipment compliance are encouraged to employ the minimum field strength necessary for communications, to provide greater attenuation of unwanted emissions than required by these regulations, and to advise the user as to how to resolve harmful interference problems."

I. Summary Remarks

16.) Current Technologies, LLC as well as other BPL proponents claim that BPL systems will not cause harmful interference when operated at the limits specified in part 15 of the FCC rules. The implicit assumption underlying these claims is that licensed radio services must tolerate the fields associated with the absolute limits of part 15 (e.g. +30μV/meter at 30 meters). Simple calculations show that this level of emissions will cause high levels of interference to HF users that are located in close proximity to BPL systems even in urban settings where noise levels are already unusually high. FCC Part 15 clearly states that in addition to meeting absolute limits for radiated emissions, unintentional radiators must not cause harmful interference. With large-scale deployment of BPL, the likelihood will be very high that BPL systems will "pass" in close proximity to licensed users. It will, in fact, be inevitable. BPL proponents need to move beyond their collective denial of its interference potential and present the commission with a clear plan that is both technically sound and economically viable as to how they intend to mitigate the inevitable interference that will result from the deployment of this technology. Simply asking incumbent services to "live with it" is not sufficient. Before rushing forward with large-scale deployment of BPL technology, I urge the commission to conduct a careful assessment of its interference potential. This assessment should include ample time for independent measurements of emissions from BPL trial sites and review of technical data by all stakeholders. This assessment should also consider the technical and economic viability of interference mitigation. If viable interference mitigation is not possible, I strongly urge the commission to explore other alternatives to “last-mile” broadband delivery (e.g. Fiber-to-the-home (FTTH), MMDS, LMDS, Wi-Fi, pole-to-pole wireless, etc).

17.) The above reply comments are timely filed via ECFS and are submitted in accordance with 47 C.F.R. § 1.415. They have been mailed on August 18, 2003 to Mr. Verveer and Mr. Lazarus at the addresses given in the comments of Current Technologies, LLC.

Respectfully Submitted,

/s/

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